RICH Reconstruction

Fermilab Meeting, Feb 2003
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- Reconstruction Algorithms & Code
- Event Display
- Raw Likelihood Ratio Distribution
- Likelihood Ratio Cut
- Efficiency for Particle Identification
- TOF Study
- Next Step

Reconstruction Algorithms

WA89: maximum likelihood method

- Given ring center & momentum $\rightarrow$ predict rings radii for mass hypotheses π, K and p
- Assume gaussian distribution of the measured radii, the signal is

$$S_j\left(\vec{x}^{(i)}\right) = \frac{n_j}{2\pi R_j}\frac{1}{\sqrt{2\pi}\sigma}e^{-\frac{\left(r^{(i)}-R_j\right)^2}{2\sigma^2}}$$

- Probability to observe exactly m PMT's

$$P(m\,\mathrm{PMT's}) = \frac{e^{-p_j}p_j^m}{m!}$$

where $p_j=s_j+b$. s_j and b are the expected number of signal and background PMT's respectively.

Reconstruction Algorithms

– Likelihood function for hypothesis *j* (π, K and p)

$$L_j = P(m) \times \prod_{i=1}^{m} \frac{S_j\left(\vec{x}^{(i)}\right) + B\left(\vec{x}^{(i)}\right)}{s_j + b}$$

$$L_j = \frac{e^{-b}}{m!} e^{-s_j} \prod_{i=1}^{m} \left(\frac{n_j}{2\pi R_j} \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{\left(r^{(i)} - R_j\right)^2}{2\sigma^2}} + B\left(\vec{x}^{(i)}\right) \right)$$

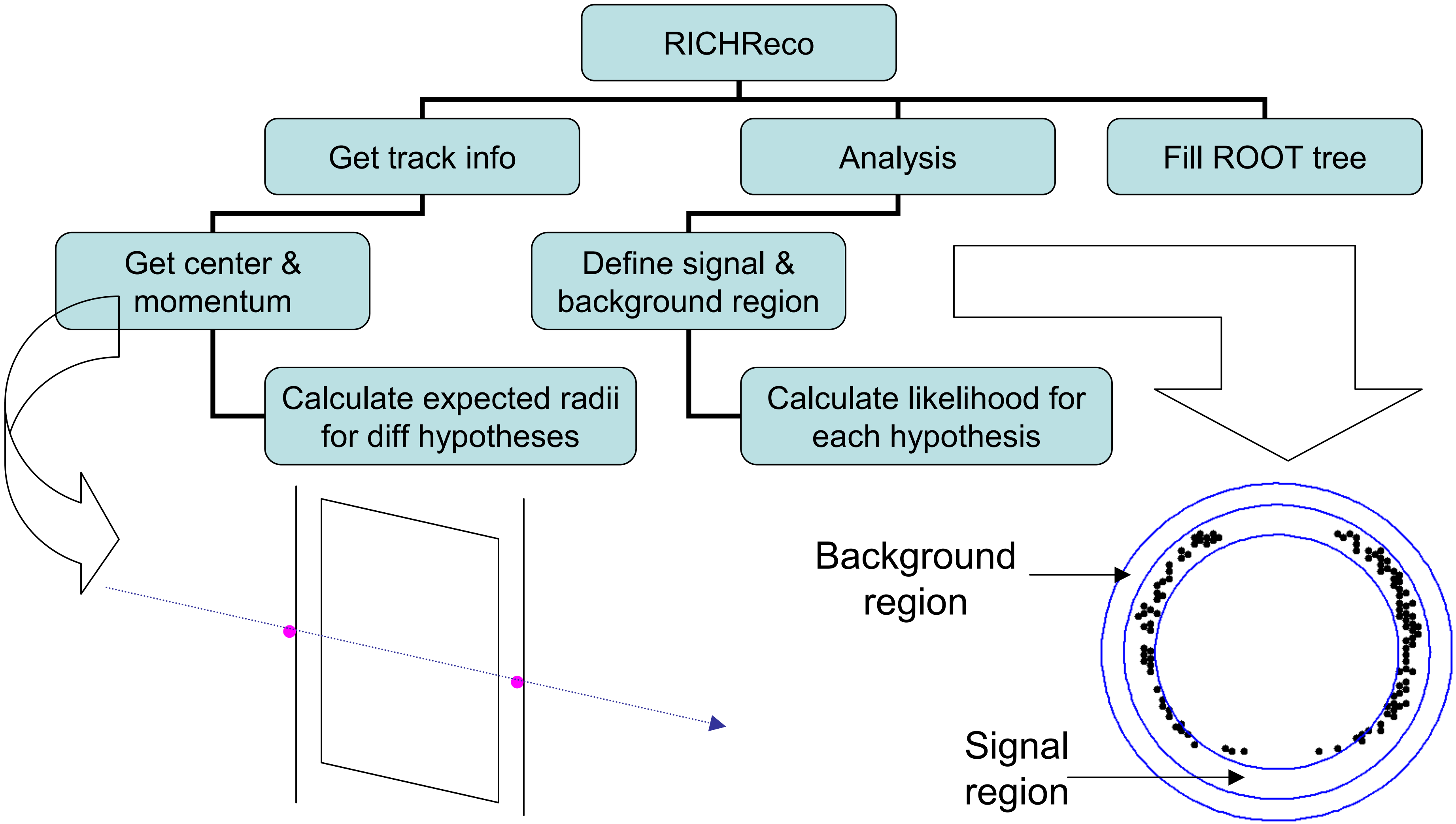
– Likelihood ratio

$$R_{ij} = \frac{L_i}{L_j}$$

3 different likelihood ratios:

$$R_{\pi K} = \frac{L_\pi}{L_K}, \quad R_{\pi p} = \frac{L_\pi}{L_p}, \quad R_{Kp} = \frac{L_K}{L_p}$$

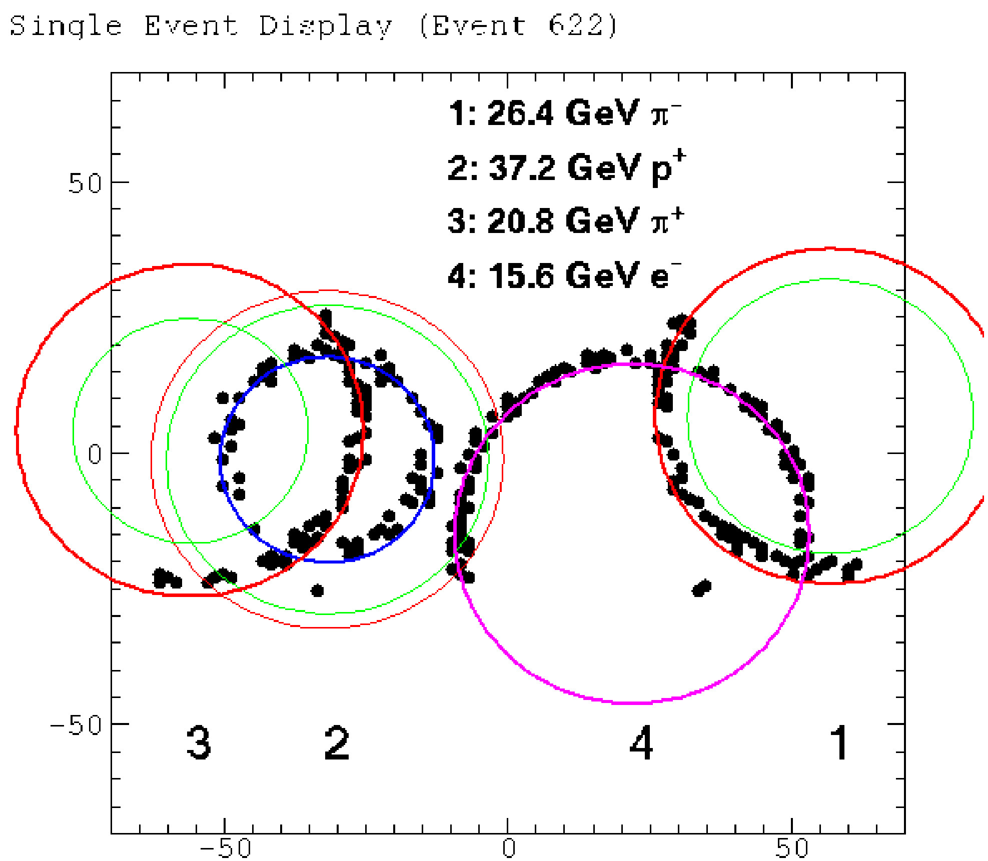
Reconstruction Code Flow Chart



Reconstruction Code

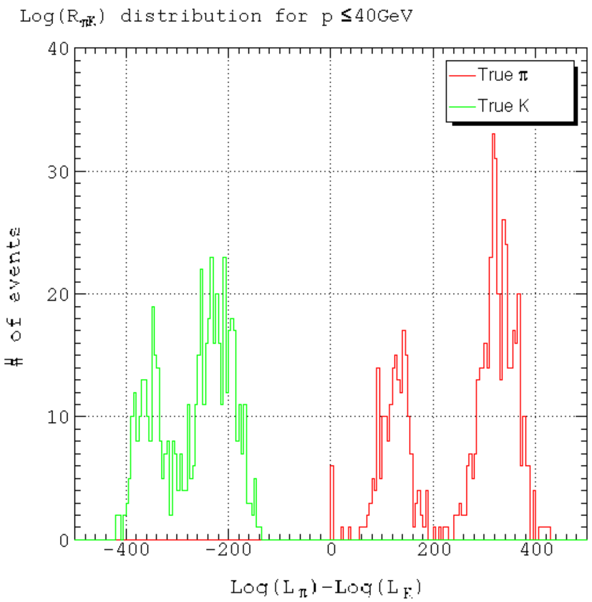
- Current Code
  - Get track info
    - MC true momentum of a track is used and will be replaced once track reconstruction is in place
    - Only tracks that pass through both upstream & downstream DCs are considered
    - Constant index of refraction is used to calculate expected ring radii for different particle hypotheses
  - Analysis
    - Signal region: $(R_{smallest}-3cm)$ to $(R_{largest}+3cm)$
    - Background region: $(R_{smallest}+3cm)$ to $(R_{largest}+8cm)$
    - Assume space resolution σ = 0.55cm
    - Assume n_e=100 (94 digits for proton ring @ 40GeV) and $n_j=n_e(R_j/R_e)^2$ → PMT efficiency is not taken into account

Event Display

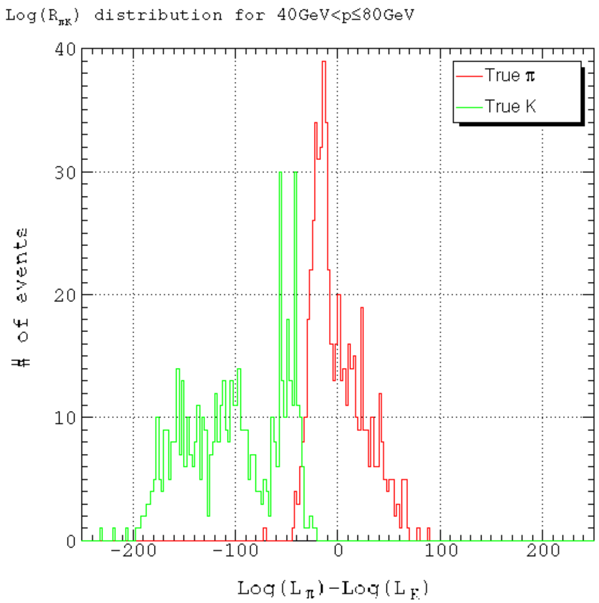


$Log(R_{\pi K})$ Raw Distribution for Different Momentum Ranges

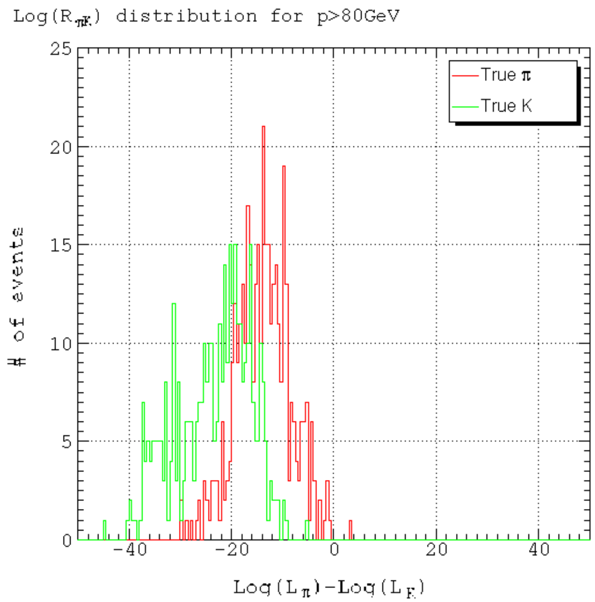
p≤40GeV



40GeV<p≤80GeV



p>80GeV

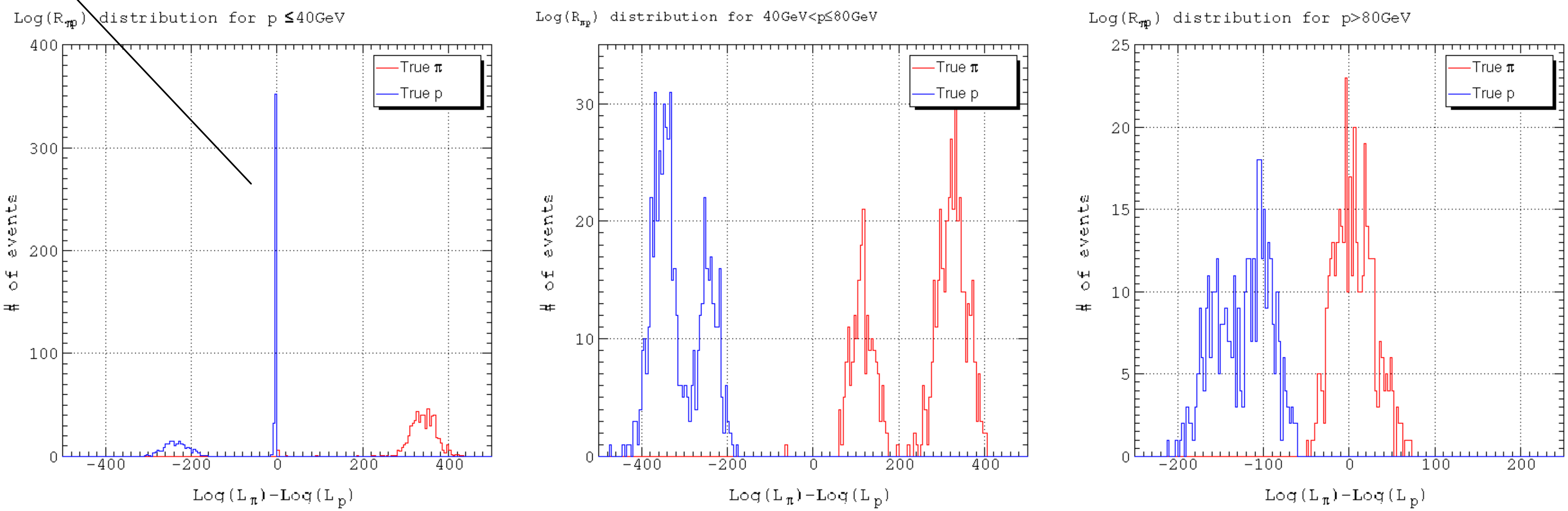


Likelihood ratio cut value changes as a function of momentum
Probably due to constant expected PMT's assumption

$Log(R_{\pi p})$ Raw Distribution for Different Momentum Ranges

Tracks below threshold momentum or with too few digits

p≤40GeV 40GeV<p≤80GeV p>80GeV

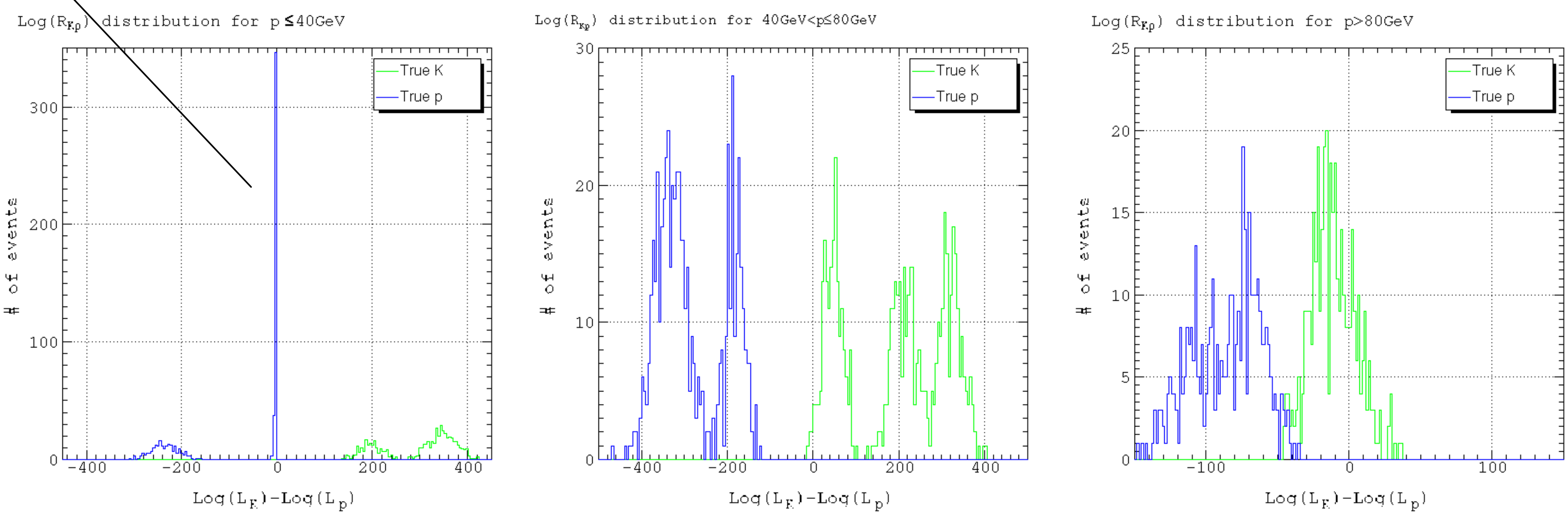


Likelihood ratio cut value changes as a function of momentum
Probably due to constant expected PMT's assumption

Log(R_{Kp}) Raw Distribution for Different Momentum Ranges

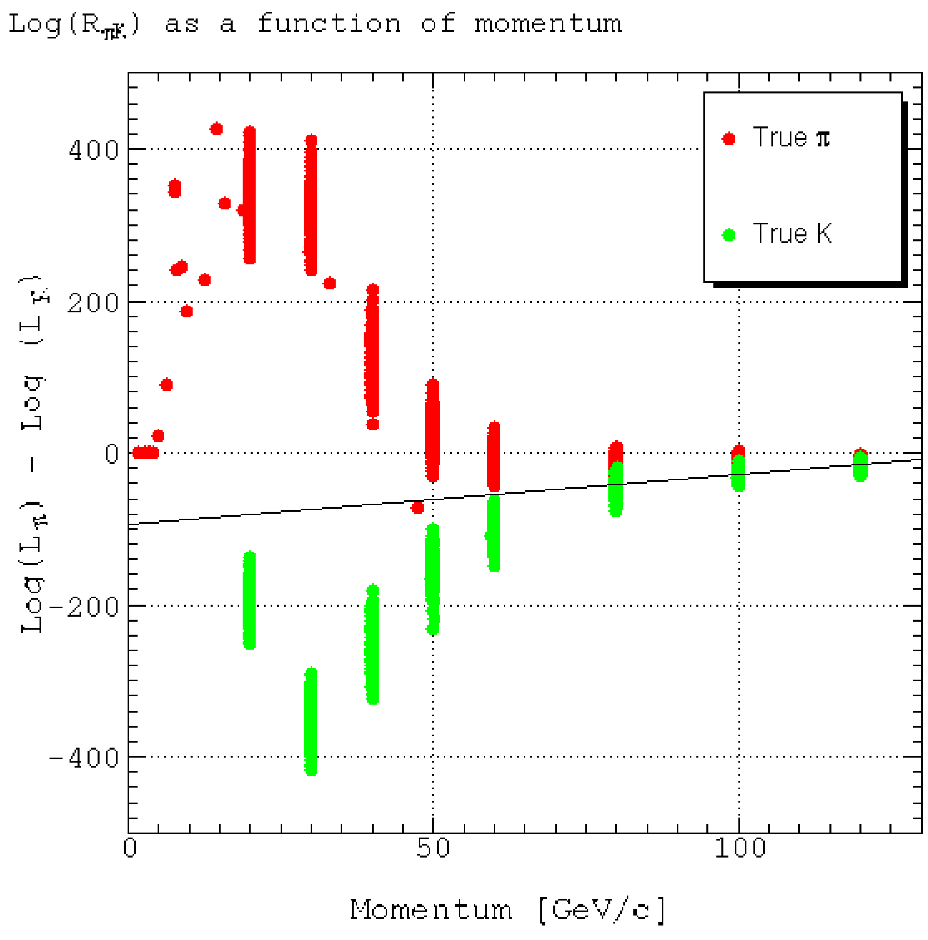
Tracks below threshold momentum or with too few digits

p≤40GeV 40GeV<p≤80GeV p>80GeV

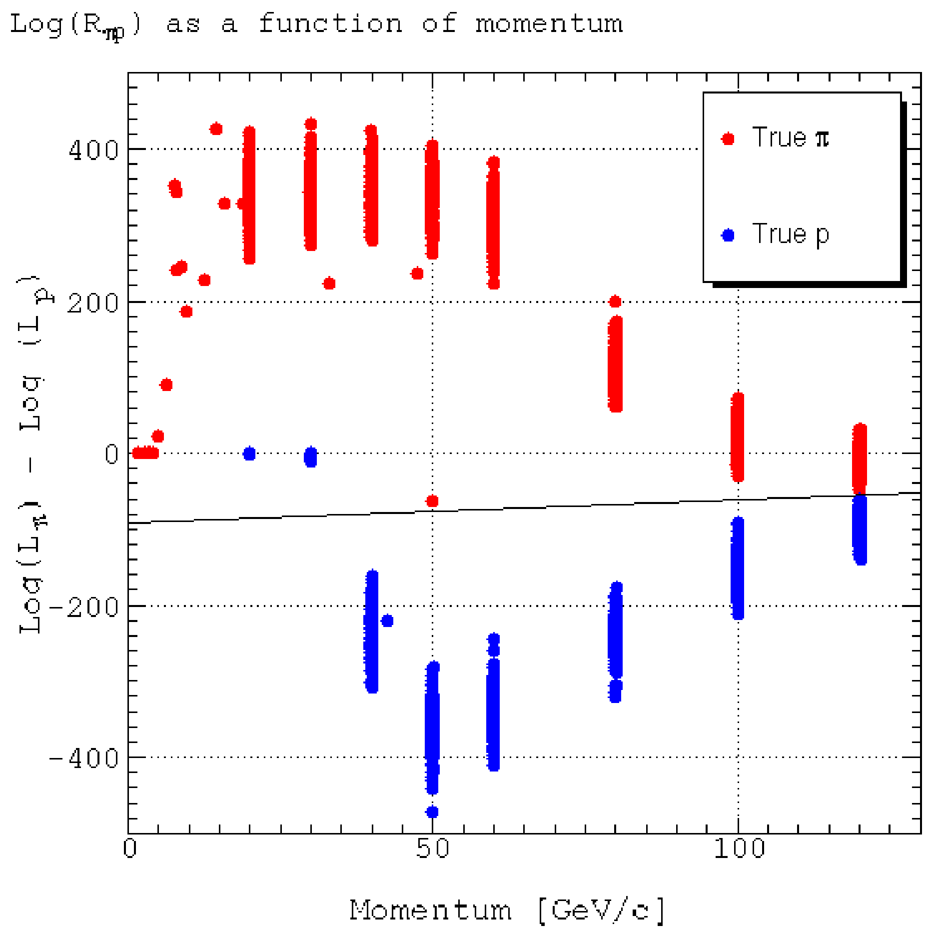


Likelihood ratio cut value changes as a function of momentum
Probably due to constant expected PMT's assumption

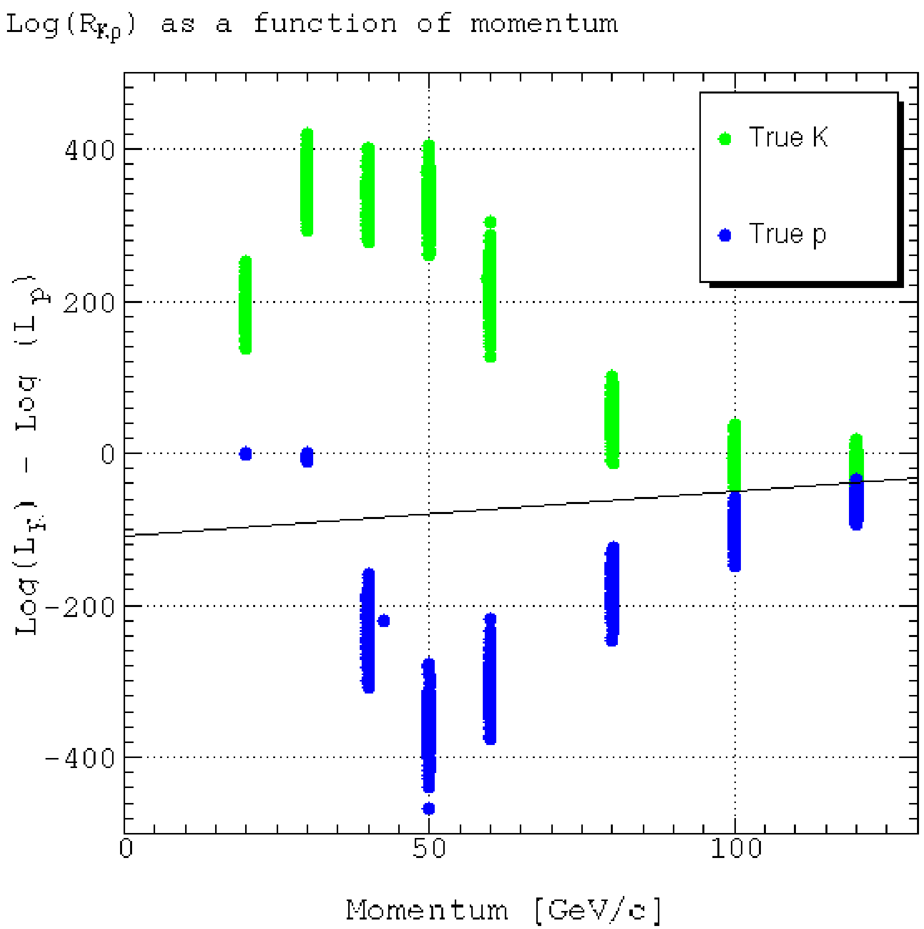
Likelihood Ratio Cut
Log($R_{\pi K}$) vs. Momentum



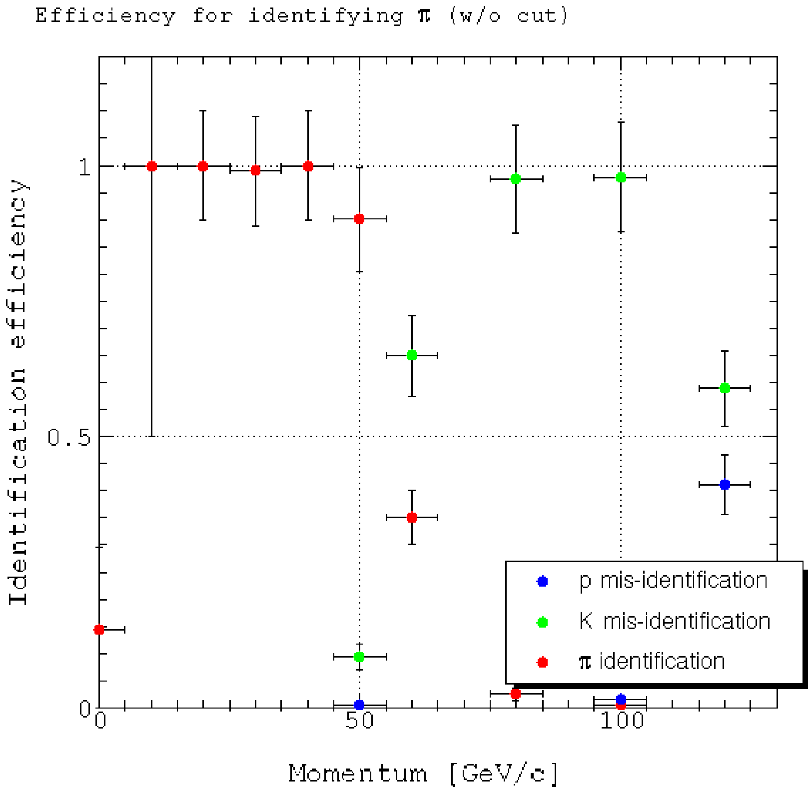
Likelihood Ratio Cut
Log($R_{\pi p}$) vs. Momentum

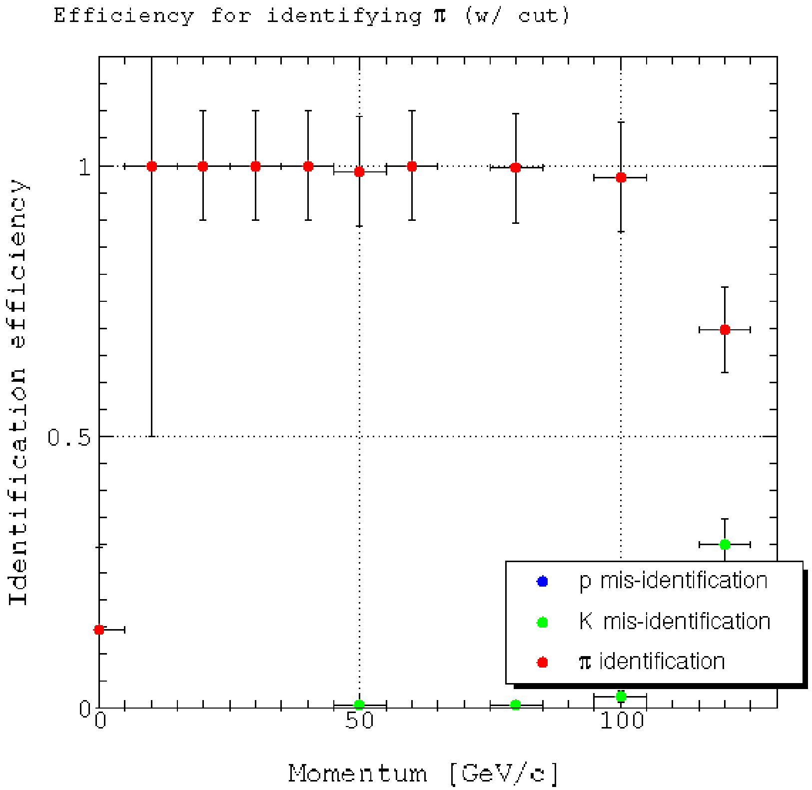


Likelihood Ratio Cut
Log(R_{Kp}) vs. Momentum



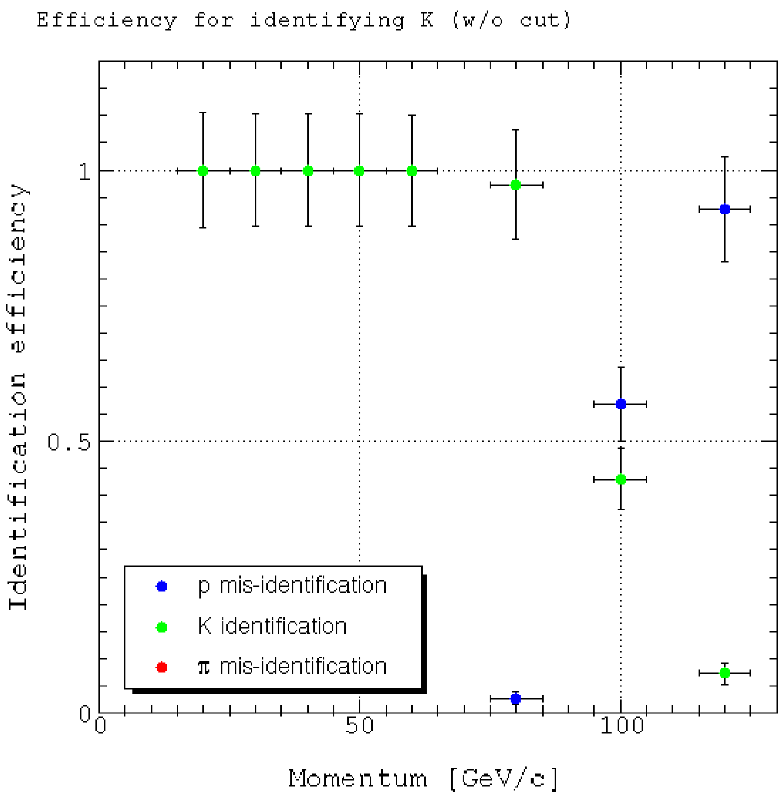
Efficiency for Identifying π

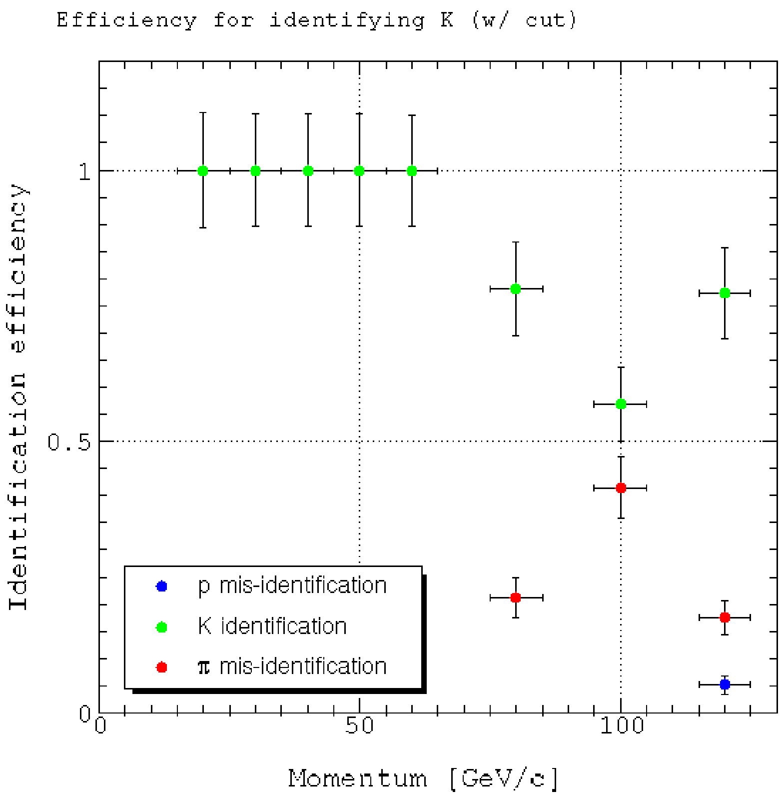




$$Efficiency = \frac{\#\pi \text{ identified}}{\#\pi \text{ from MC}}$$

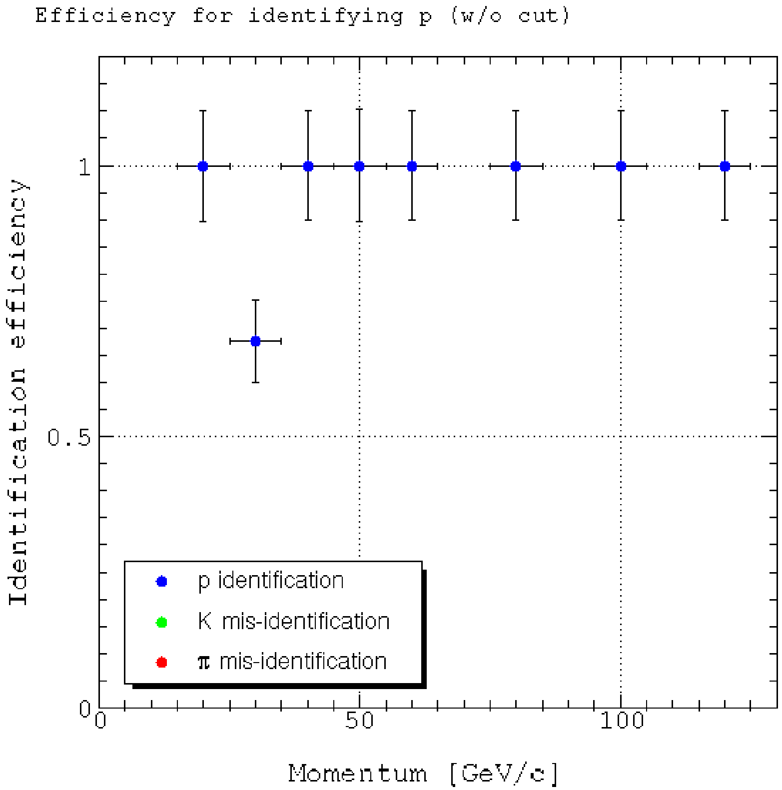
Efficiency for Identifying K

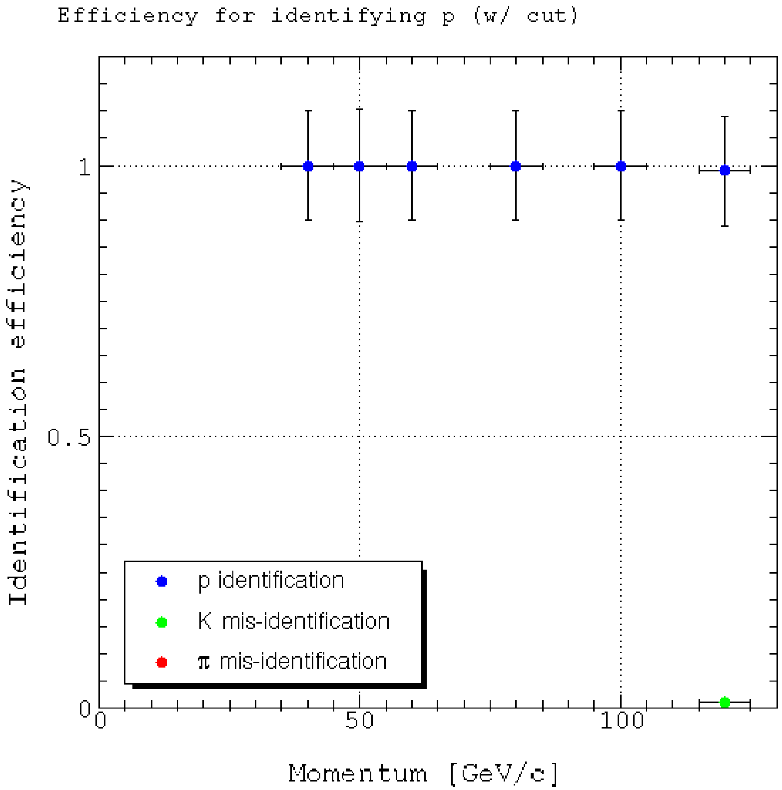




$$Efficiency = \frac{\# K \text{ identified}}{\# K \text{ from MC}}$$

Efficiency for Identifying p





$$Efficiency = \frac{\#\, p \text{ identified}}{\#\, p \text{ from MC}}$$

RICH Data Stream

RICHRing Class

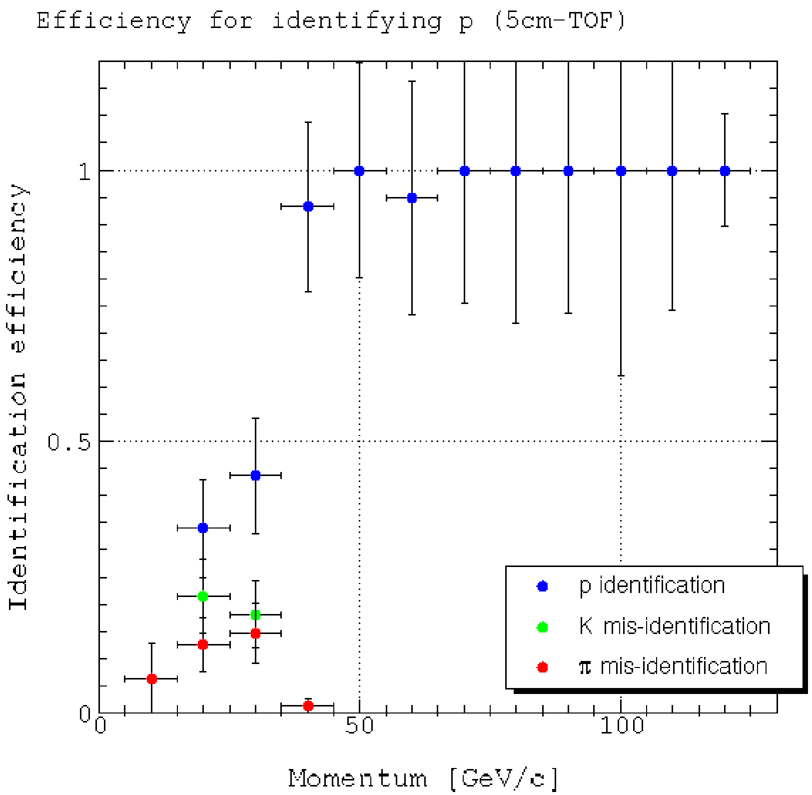
- PMT's
- Ring center
- Momentum
- Reconstructed particle ID
- Expected radii of all hypotheses (e, π, K, p)
- Likelihood of all hypotheses (e, π, K, p)

TOF Study

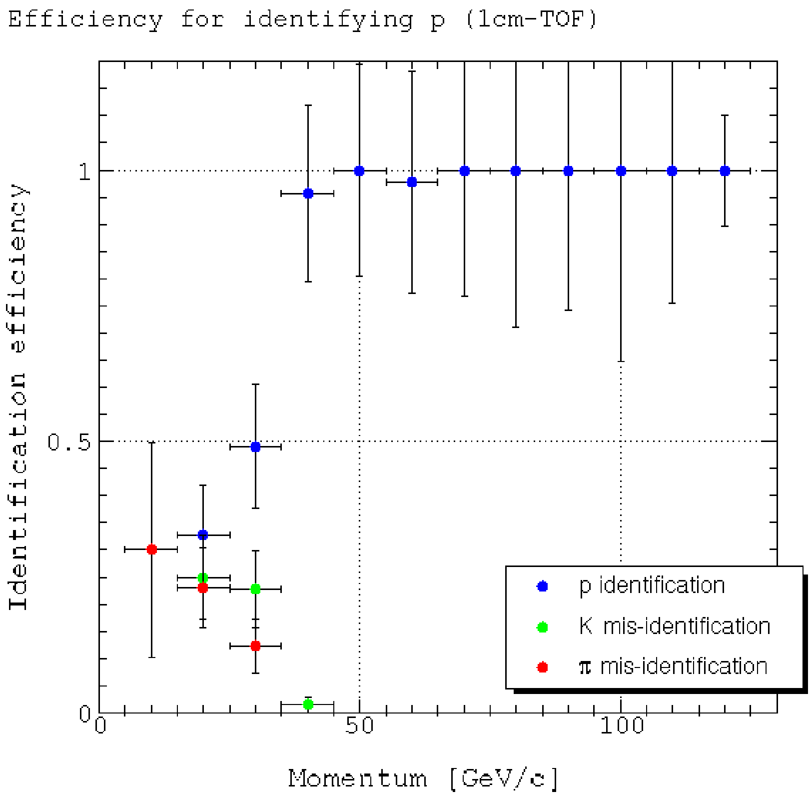
	5cm-TOF			1cm-TOF		
	True	Reco	Reco / True	True	Reco	Reco / True
# e	79	56	71%	72	43	60%
# π	478	338	71%	475	330	70%
# K	40	31	78%	38	29	76%
# p	609	517	85%	620	541	87%

TOF Study: Efficiency for Identifying p

5cm-TOF



1cm-TOF



Next Step

- RICH reconstruction: almost complete
  - Vary signal & background regions to optimize ring reconstruction
  - Calculate expected number of PMT’s
- Get momentum & direction for each track from previous reconstruction stage